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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	7426-073	Total Pages
First Named Inventor or Application Identifier		
S. Takeda et al.		
Express Mail Label No.	EL 394 218 118 US	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

- ☒ Fee Transmittal Form
Submit an original, and a duplicate for fee processing) [Total 44 Pages]
- ☒ Specification (Preferred arrangement set forth below) [Total 44 Pages]
-Descriptive title of the Invention
-Cross Reference to Related Applications
-Statement Regarding Fed sponsored R&D
-Reference to Microfiche Appendix
-Background of the Invention
-Brief Summary of the Invention
-Brief Description of the Drawings (if filed)
-Detailed Description of the Invention (including drawings, if filed)
-Claim(s)
-Abstract of the Disclosure
- ☒ Drawing(s) (35 USC 113) [Total 2 Sheets]
- ☒ Oath or Declaration [Total 3 Sheets]
a. ☐ Newly executed (original or copy)
b. ☒ Copy from a prior application (37 CFR 1.63(d))
(for continuation/divisional with Box 17 completed)
[Note Box 5 below]
☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33 (b).
- ☒ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

- ☐ Microfiche Computer Program (Appendix)
- ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
a. ☐ Computer Readable Copy
b. ☐ Paper Copy (identical to computer copy)
c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

- ☐ Assignment Papers (cover sheet & document(s))
- ☐ 37 CFR 3.73(b) Statement of Power of Attorney (when there is an assignee)
- ☐ English Translation Document (if applicable)
- ☐ Information Disclosure Copies of IDS Statement (IDS)/PTO-1449 Citations
- ☒ Preliminary Amendment
- ☒ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
- ☐ Small Entity Statement filed in prior application, Statement(s) Status still proper and desired
- ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)
- ☐ Other:

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:
☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: 08/981,702 filed January 6, 1998.

18. CORRESPONDENCE ADDRESS

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Prior application: Examiner D. Graybill

Art Unit 2814

Assistant Commissioner for Patents
Box PATENT APPLICATION
Washington, D.C. 20231

Sir:

This is a request for filing a ☒ continuation ☐ divisional application under 37 CFR § 1.53(b), of pending prior application no. 08/981, 702 filed on January 6, 1998.

of Shinji TAKEDA, Takashi MASUKO, Masami YUSA, Tooru KIKUCHI, Yasuo MIYADERA, Iwao MAEKAWA, Mitsuo YAMASAKI, Akira KAGEYAMA, and Aizou KANEDA
(inventor(s) currently of record in prior application)

for MATERIAL FOR SEMICONDUCTOR DEVICE
(title of invention)

1. ☒ The filing fee is calculated below:

PATENT APPLICATION FEE VALUE

TYPE	NO. FILED	LESS	EXTRA	EXTRA RATE	FEE
Total Claims	35	-20	15	\$18.00 each	\$ 270.00
Independent	6	-3	3	\$78.00 each	\$ 234.00
Basic Fee					\$ 690.00
Multiple Dependency Fee If Applicable (\$260.00)					\$ 0.00
Total					\$ 1,194.00
50% Reduction for Independent Inventor, Nonprofit Organization or Small Business Concern					\$ 0.00
Total Filing Fee					\$ 1,194.00

2. ☒ Please charge the required fee to Pennie & Edmonds LLP Deposit Account No. 16-1150. A copy of this sheet is enclosed.
3. ☒ Amend the specification by inserting before the first line the following sentence: This is a continuation of application no. 08/981,702, filed January 6, 1998.
- 4a. ☐ Transfer the drawings from the prior application to this application and abandon the prior application as of the filing date accorded this

application. A duplicate copy of this sheet is enclosed for filing in the prior application file.

- 4b. ☒ New formal drawings are enclosed.
- 4c. ☐ Informal drawings are enclosed.
- 5a. ☒ Priority of application no. 7-171154 filed on July 6, 1995 in Japan is claimed under 35 U.S.C. §119.
- 5b. ☒ The certified copy has been filed in prior application no. 7-171154, filed July 6, 1995.
- 6. ☒ The prior application is assigned of record to Hitachi Chemical Company, Ltd.
- 7a. ☒ The Power of Attorney appears in the original papers in the prior application no. 7-171154, filed July 6, 1995.
- 7b. ☐ Since the Power of Attorney does not appear in the original papers, a copy of the Power in prior application no. , filed is enclosed.
- 8. ☐ This application contains nucleic acid and/or amino acid sequences required to be disclosed in a Sequence Listing under 37 CFR §§1.821-1.825. It is requested that the Sequence Listing in computer readable form from prior application no., filed on be made a part of the present application as provided for by 37 C.F.R. §1.821(e). The sequences disclosed therein are the same as the sequences disclosed in this application. A copy of the paper Sequence Listing from application no. is enclosed.
- 9. ☐ The undersigned states, under 37 C.F.R. §1.821(f), that the content of the enclosed paper Sequence Listing from application no. is the same as the content of the computer readable form submitted in application no. .
- 10. ☒ Additional enclosures or instructions. A Preliminary Amendment is enclosed.

Respectfully submitted,

Date April 5, 2000

24, 576

(Reg. No.)

Charles E. Miller
PENNIE & EDMONDS LLP
1155 Avenue of the Americas
New York, N.Y. 10036-2711
(212) 790-9090

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: S. Takeda et al.

Serial No.: Continuation of 08/981,702

Group Art Unit: To be assigned

Filed: Concurrently filed

Examiner: To be assigned

For: SEMICONDUCTOR DEVICE AND
PROCESS FOR FABRICATION
THEREOF

Attorney Docket No.: 7426-

New York, New York
April 5, 2000

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following amendments and remarks into the file of the present application.

IN THE CLAIMS

Please cancel claims 1-16.

Please add the following new claims:

17. A material comprising an organic die-bonding film having a water absorption of 1.5% by volume or less.

18. A material according to claim 17, having a saturation moisture absorption of 1.0% by volume or less.

19. A material according to claim 17, having a peel strength of 0.5 kgf/5 mm x 5 mm chip or higher at a stage where a semiconductor has been bonded to a support member using said material.

20. A material according to claim 18, having a peel strength of 0.5 kgf/5 mm x 5 mm chip or higher at a stage where a semiconductor has been bonded to a support member with said material.

21. A material according to claim 20, said material having a modulus of elasticity of 10 MPa or less at a temperature of 250°C.

22. A material according to claim 17, said material having a modulus of elasticity of 10 MPa or less at a temperature of 250°C.

23. A material according to claim 22, having a peel strength of 0.5 kgf/5 mm x 5 mm chip or higher at a stage where a semiconductor has been bonded to a support member with said material.

24. A material comprising an organic die-bonding film having a saturation moisture absorption of 1.0% by volume or less.

25. A material comprising an organic die-bonding film having a residual volatile component in an amount of not more than 3.0% by weight.

26. A material according to claim 24, having a residual volatile component in an amount of not more than 3.0% by weight.

27. A material comprising an organic die-bonding film having a modulus of elasticity of 10 MPa or less at a temperature of 250°C.

28. A material comprising an organic die-bonding film having a void volume of 10% or less in terms of voids present in the material and at an interface between said material and a support member at a stage where a semiconductor has been bonded to said support member.

29. A material comprising an organic die-bonding film having a peel strength of 0.5 kgf/5 mm x 5 mm chip or higher at a stage where a semiconductor has been bonded to a support member with said material.

30. A material according to claim 29, having a saturation moisture absorption of 1.0% by volume or less.

31. A material according to claim 29, having a residual volatile component in an amount of not more than 3.0% by weight.

32. A material according to claim 30, having a residual volatile component in an amount of not more than 3.0% by weight.

33. A material according to claim 29, having a modulus of elasticity of 10 MPa or less at a temperature of 250°C.

34. A material according to claim 17, including at least one component selected from an epoxy resin, a silicon resin, an acryl resin and a polyimide resin.

35. A material according to claim 34, said component including a polyimide resin.

36. A material according to claim 34, said component including an epoxy resin, said epoxy resin being any one of glycidyl ether, glycidylamine, glycidyl ester and an alicyclic epoxy resin.

37. A material according to claim 27, including at least one component selected from an epoxy resin, a silicon resin, an acryl resin and a polyimide resin.

38. A material according to claim 37, said component including a polyimide resin.

39. A material comprising an organic die-bonding film according to claim 21, said component including an epoxy resin, said epoxy resin being any one of glycidyl ether, glycidylamine, glycidyl ester and an alicyclic epoxy resin.

40. A material comprising an organic die-bonding film according to claim 1, further including an inorganic filler.

41. A material comprising an organic die-bonding film according to claim 27, further including an inorganic filler.

42. A method of bonding a semiconductor chip to a support member wherein said material comprising an organic die-bonding film according to claim 17 is used for said bonding.

43. A method of bonding according to claim 42, wherein said bonding is carried out at a temperature of 100-350°C for a time period of 0.1 second - 20 seconds with a pressure of 0.1 - 20gf/mm².

44. A method of bonding according to claim 43, wherein said bonding is carried out at a temperature of 150 - 250°C for a time period not longer than 2 seconds, with a pressure of 4 gf/mm² or less.

45. A method of bonding according to claim 44, wherein said bonding is carried out for a time period 1.5 seconds or less, with a pressure of 0.3 - 2 gf/mm².

46. A method of bonding the support member to the semiconductor chip with a material comprising an organic die-bonding film according to claim 27.

47. A method of bonding according to claim 46, wherein said bonding is carried out at a temperature of 100 - 350°C for a time period of 0.1 second - 20 seconds with a pressure of 0.1-20 gf/mm².

48. A method of bonding according to claim 47, wherein said bonding is carried out at a temperature of 150 - 250°C for a time period of less than 2 seconds with a pressure of 4 gf/mm².

49. A method of bonding according to claim 48, wherein said bonding is carried out for a time period of 1.5 seconds or less with a pressure of 0.3- 2 gf/mm².

50. A semiconductor device manufactured using a material comprising an organic die-bonding film according to claim 17.

51. A semiconductor device manufactured using a material comprising an organic die-bonding film according to claim 27.

REMARKS

There are claims 17-51. The support for the amendment can be found in the specification, claims and drawings as originally filed. Thus, no new matter is believed to be introduced.


No fee is believed to be due for this amendment. Should any fee be required, please charge same to Deposit Account No. 16-1150.

CONCLUSION

Applicants respectfully request that the amendments and remarks made herein be entered and made of record in the file history of the present application.

Respectfully submitted,

Date: April 5, 2000



Charles E. Miller

24,576

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SPECIFICATION

SEMICONDUCTOR DEVICE AND
PROCESS FOR FABRICATION THEREOF

5

TECHNICAL FIELD

This invention relates to a semiconductor device having a support member such as a lead frame to which a semiconductor die or chip is attached using a die-bonding material and encapsulated with resin, and a process for the fabrication of such a semiconductor device.

BACKGROUND ART

15

As methods by which semiconductor chips are attached to lead frames, a method has been used in which a die-bonding material is fed onto the lead frame and the semiconductor chip is bonded thereto.

20

Such a die-bonding material is known to include, e.g., Au-Si eutectics, solders and resin pastes. Of these, Au-Si eutectics have problems in that they are expensive, have a high modulus of elasticity, and require vibration at the bonding portion. The solders have problems in that they can not withstand

25

temperatures equal to or greater than their melting temperature and have a high modulus of elasticity.

As for the resin pastes, silver paste is the most commonly available. Compared with other materials, silver paste is inexpensive, has a high heat resistance reliability and has a low modulus of elasticity. Hence, they are most widely used as bonding materials for the lead frames of ICs and LSIs.

In recent years, there has been a rapid increase in demand for high-density packaging as electronic machinery has been made smaller in size and thickness. In semiconductor packaging, conventional pin insertion packaging has been substituted by surface packaging, which has become the prevailing packaging method suitable for high-density packaging.

In surface packaging, in order to directly solder leads to printed-wiring substrates, packaging is carried out by infrared reflowing, vapor phase reflowing or solder dipping while heating the whole package.

During this packaging, the whole package is exposed to high temperatures of 210°C to 260°C. Hence, any presence of moisture in the package causes explosive vaporization of the moisture to cause package cracks (hereinafter "reflow cracks").

Such reflow cracks may cause a great lowering of the reliability of semiconductor packages, bringing about a serious technical problem.

The mechanism by which reflow cracks ascribable to die-bonding materials occur is as follows: During storage of semiconductor packages, (1) die-bonding materials absorb moisture, (2) this moisture is vaporized upon heating when

packaged by reflowing and soldering, and (3) vapor pressure thus produced causes breaking or separation of the die-bonding material layers, (4) so that the reflow cracks occur.

While reflow crack resistance of encapsulant has been improved, the reflow cracks ascribable to die-bonding materials provide a serious matter especially in thin-type packaging. Thus, it is strongly sought to improve its reflow crack resistance.

The silver paste, having been most commonly used, tends to cause reflow cracks because it has become difficult with the increase in size of chips to uniformly coat the silver paste on the whole surface requiring area and also because it is pasty itself and therefore tends to cause voids in bonding layers.

DISCLOSURE OF THE INVENTION

The present invention provides a semiconductor device that employs a filmy organic die-bonding material, may cause no reflow cracks and has good reliability, and a process for fabrication thereof.

In the present invention, a filmy organic die-bonding material is used. This filmy organic material is such a filmy material that is mainly made of an organic material such as epoxy resin, silicone resin, acrylic resin, or polyimide resin (including an organic material containing a metal filler or an inorganic material filler added thereto). The filmy organic die-bonding material which has been heated is contact-bonded to a support

member such as a lead frame, and a semiconductor chip is placed on the filmy organic die-bonding material and heat is applied to bond the chip. More particularly, resin paste is provided in the form of a film so that die-bonding material is uniformly applied to the bonding portion.

Fig. 1 illustrates an example of a process for fabricating the semiconductor device of the present invention.

The filmy organic die-bonding material 1 is cut in a prescribed size with a cutter 2 ((a) in Fig. 1).

The filmy organic die-bonding material 1 is contact-bonded to a die pad 6 of a lead frame 5 on a heating platen 7 by means of a contact press ((b) in Fig. 1). The contact bonding may preferably be carried out under conditions of a temperature of from 100°C to 250°C, a press time of from 0.1 second to 20 seconds and a pressure of from 4 gf/mm² to 200 gf/mm².

A semiconductor chip 8 is put on the filmy organic die-bonding material 1 stuck to the die pad 6, followed by heat contact bonding (i.e., die bonding) ((c) in Fig. 1). The die bonding may preferably be carried out under conditions of a temperature of from 100°C to 350°C, a bonding time of from 0.1 second to 20 seconds and a pressure of from 0.1 gf/mm² to 30 gf/mm². More preferable conditions for die bonding are of a temperature of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 2 seconds and a pressure of 0.1 gf/mm² to 4 gf/mm², and the most preferable conditions for die bonding are of a temperature of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 1.5

(exclusive) seconds and a pressure of 0.3 gf/mm² to 2 gf/mm².

Then, the step of wire bonding ((d) in Fig. 1) follows, and the step of encapsulating the semiconductor chip with resin ((e) in Fig. 1) further follows. Thus, the semiconductor device is
5 produced. Reference numeral 9 denotes an encapsulant resin.

For example, the filmy organic die-bonding material of the present invention is prepared by dissolving or dispersing an organic material such as polyimide or epoxy resin and optionally an additive such as a metal filler in an organic solvent to obtain a
10 coating varnish, coating this coating varnish on a carrier film such as biaxially stretched polypropylene film, followed by evaporation of the solvent, and peeling the filmy material from the carrier film. When prepared in this way, a film having self-supporting properties can be obtained.

15 The present inventors have discovered that the occurrence of reflow cracks in semiconductor device correlates with the properties or characteristics of the filmy organic die-bonding material, and have made detailed studies on the relationship between the occurrence of reflow cracks and the characteristics
20 of the filmy organic die-bonding material. As a result, they have accomplished the present invention.

According to a first embodiment of the present invention, the semiconductor device and the process for its fabrication are characterized in that, in the semiconductor device having a
25 support member to which a semiconductor chip is attached using a die-bonding material and encapsulated with resin, a filmy

organic die-bonding material having a water absorption of 1.5% by volume or less is used as the die-bonding material.

According to a second embodiment of the present invention, the semiconductor device and the process for its fabrication are
5 characterized in that, in the semiconductor device having a support member to which a semiconductor chip is attached using a die-bonding material and then encapsulated with resin, a filmy organic die-bonding material having a saturation moisture
absorption of 1.0% by volume or less is used as the die-bonding
10 material.

According to a third embodiment of the present invention, the semiconductor device and the process for its fabrication are characterized in that, in the semiconductor device having a
support member to which a semiconductor chip is attached using
15 a die-bonding material and then encapsulated with resin, a filmy organic die-bonding material having a residual volatile component in an amount not more than 3.0% by weight is used as the die-bonding material.

According to a fourth embodiment of the present invention,
20 the semiconductor device and the process for its fabrication are characterized in that, in the semiconductor device having a support member to which a semiconductor chip is attached using a die-bonding material and then encapsulated with resin, a filmy organic die-bonding material having a modulus of elasticity of 10
25 MPa or less at a temperature of 250 °C is used as the die-bonding material.

According to a fifth embodiment of the present invention, the semiconductor device and the process for its fabrication are characterized in that, in the semiconductor device having a support member to which a semiconductor chip is attached using a die-bonding material and then encapsulated with resin, a filmy organic die-bonding material having, at the stage where the semiconductor chip is bonded to the support member, a void volume of 10% or less in terms of voids present in the die-bonding material and at the interface between the die-bonding material and the support member is used as the die-bonding material.

According to a sixth embodiment of the present invention, the semiconductor device and the process for its fabrication are characterized in that, in the semiconductor device having a support member to which a semiconductor chip is attached using a die-bonding material and then encapsulated with resin, a filmy organic die-bonding material having a peel strength of $0.5 \text{ Kg}/5 \times 5 \text{ mm}$ chip or above at the stage where the semiconductor chip is bonded to the support member is used as the die-bonding material.

According to a seventh embodiment of the present invention, the semiconductor device and the process for its fabrication are characterized in that, in the semiconductor device having a support member to which a semiconductor chip is attached using a die-bonding material and then encapsulated with resin, a filmy organic die-bonding material i) having a planar dimension not larger than the planar dimension of the semiconductor chip, and

- ii) not protruding outward from the region of the semiconductor chip (i.e., not to protrude from the interface between the semiconductor chip and the support member) at the stage where the semiconductor chip is bonded to the support member is used as the die-bonding material.

In the embodiments of the present invention, the values of the properties or characteristics of the filmy organic die-bonding materials, such as a water absorption of 1.5% by volume or less, a saturation moisture absorption of 1.0% by volume or less, a residual volatile component in an amount not more than 3.0% by weight, or a modulus of elasticity of 10 MPa or less at a temperature of 250 °C, are the values measured at the stage before the filmy organic die-bonding material is stuck onto the support member.

- The filmy organic die-bonding material used in the first embodiment of the present invention, having a water absorption of 1.5% by volume or less, the filmy organic die-bonding material used in the second embodiment of the present invention, having a saturation moisture absorption of 1.0% by volume or less, the filmy organic die-bonding material used in the fourth embodiment of the present invention, having a modulus of elasticity of 10 MPa or less at a temperature of 250 °C, and the filmy organic die-bonding material used in the sixth embodiment of the present invention, having a peel strength of 0.5 Kg/5 × 5 mm chip or above at the stage where the semiconductor chip is bonded to the support member, can be produced by controlling composition of

the filmy organic die-bonding material, e.g., the structure of polymers such as polyimide and the content of fillers such as silver.

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The filmy organic die-bonding material used in the third
5 embodiment of the present invention, having a residual volatile
component in an amount not more than 3.0% by weight, and the
filmy organic die-bonding material used in the fifth embodiment
of the present invention, having, at the stage where the
semiconductor chip is bonded to the die-bonding material, a void
10 volume of 10% or less in terms of voids present in the die-
bonding material and at the interface between the die-bonding
material and the support member, can be produced by controlling
the conditions for producing the filmy organic die-bonding
material, e.g., drying temperature, drying time and so forth.

15 The semiconductor chip includes commonly available
semiconductor chips of ICs, LSIs, VLSIs and so forth, any of which
may be used. The die bonding materials according to the present
invention is suitably used for the semiconductor chip as large a 5
× 5 mm or larger. The support member includes lead frames having
20 die pads, ceramic wiring boards and glass-polyimide wiring
boards, any of which may be used. Fig. 3 shows a plan view of an
example of lead frames having die pads. The lead frame 40 shown
in Fig. 3 has die pads 41.

As the filmy organic die-bonding material, not only those
25 having single-layer structure but also those having multi-layer
structure may be used.

In the present invention, the filmy organic die-bonding material may have at the same time two or more properties or characteristics of those described above.

For example, properties or characteristics the filmy organic die-bonding material may preferably have at the same time are as follows:

- (1) A filmy organic die-bonding material having a saturation moisture absorption of 1.0% by volume or less and a residual volatile component in an amount not more than 3.0% by weight;
- 10 (2) A filmy organic die-bonding material having a saturation moisture absorption of 1.0% by volume or less, and a peel strength of 0.5 Kg/5 × 5 mm chip or above at the stage where the semiconductor chip is bonded to the support member;
- (3) A filmy organic die-bonding material having a residual
15 volatile component in an amount not more than 3.0% by weight and a peel strength of 0.5 Kg/5 × 5 mm chip or above at the stage where the semiconductor chip is bonded to the support member;
and
- (4) A filmy organic die-bonding material having a saturation
20 moisture absorption of 1.0% by volume or less, a residual volatile component in an amount not more than 3.0% by weight, and a peel strength of 0.5 Kg/5 × 5 mm chip or above at the stage where the semiconductor chip is bonded to the support member.

In the present invention, the foregoing properties or
25 characteristics of the filmy organic die-bonding material may be in any combination in accordance with the purposes for which it

is used.

The above (1) to (4) filmy organic die-bonding materials or the filmy organic die-bonding materials having the above properties or characteristics in any other combinations may preferably be used as filmy organic die-bonding materials each i) having a planar dimension not larger than the planar dimension of the semiconductor chip, and ii) not protruding outward from the region of the semiconductor chip at the stage where the semiconductor chip is bonded to the support member.

The semiconductor device of the present invention is free from reflow cracks which might otherwise occur during reflow soldering for the packaging of semiconductor devices, and has good reliability.

As the organic material constituting the filmy organic die-bonding material of the present invention, polyimide resin is preferred.

Tetracarboxylic dianhydrides used as starting materials for the polyimide resin include:

- 1,2-(ethylene)bis(trimellitate anhydride),
- 1,3-(trimethylene)bis(trimellitate anhydride),
- 1,4-(tetramethylene)bis(trimellitate anhydride),
- 1,5-(pentamethylene)bis(trimellitate anhydride),
- 1,6-(hexamethylene)bis(trimellitate anhydride),
- 1,7-(heptamethylene)bis(trimellitate anhydride),
- 1,8-(octamethylene)bis(trimellitate anhydride),
- 1,9-(nonamethylene)bis(trimellitate anhydride),

- 1,10-(decamethylene)bis(trimellitate anhydride),
1,12-(dodecamethylene)bis(trimellitate anhydride),
1,16-(hexadecamethylene)bis(trimellitate anhydride),
1,18-(octadecamethylene)bis(trimellitate anhydride),
5 pyromellitic dianhydride,
3,3',4,4'-diphenyltetracarboxylic dianhydride,
2,2',3,3'-diphenyltetracarboxylic dianhydride,
2,2-bis(3,4-dicarboxyphenyl)propane dianhydride,
2,2-bis(2,3-dicarboxyphenyl)propane dianhydride,
10 1,1-bis(2,3-dicarboxyphenyl)ethane dianhydride,
1,1-bis(3,4-dicarboxyphenyl)ethane dianhydride,
bis(2,3-dicarboxyphenyl)methane dianhydride,
bis(3,4-dicarboxyphenyl)methane dianhydride,
bis(3,4-dicarboxyphenyl)sulfone dianhydride,
15 3,4,9,10-perylenetetracarboxylic dianhydride,
bis(3,4-dicarboxyphenyl)ether dianhydride,
benzene-1,2,3,4-tetracarboxylic dianhydride,
3,4,3',4'-benzophenonetetracarboxylic dianhydride,
2,3,2',3'-benzophenonetetracarboxylic dianhydride,
20 2,3,3',4'-benzophenonetetracarboxylic dianhydride,
1,2,5,6-naphthalenetetracarboxylic dianhydride,
2,3,6,7-naphthalenetetracarboxylic dianhydride,
1,2,4,5-naphthalene-tetracarboxylic dianhydride,
1,4,5,8-naphthalene-tetracarboxylic dianhydride,
25 2,6-dichloronaphthalene-1,4,5,8-tetracarboxylic dianhydride,
2,7-dichloronaphthalene-1,4,5,8-tetracarboxylic dianhydride,

005040 2424560

- 2,3,6,7-tetrachloronaphthalene-1,4,5,8-tetracarboxylic dianhydride,
phenanthrene-1,8,9,10-tetracarboxylic dianhydride,
pyrazine-2,3,5,6-tetracarboxylic dianhydride,
5 thiophene-2,3,4,5-tetracarboxylic dianhydride,
2,3,3',4'-biphenyltetracarboxylic dianhydride,
3,4,3',4'-biphenyltetracarboxylic dianhydride,
2,3,2',3'-biphenyltetracarboxylic dianhydride,
bis(3,4-dicarboxyphenyl)dimethylsilane dianhydride,
10 bis(3,4-dicarboxyphenyl)methylphenylsilane dianhydride,
bis(3,4-dicarboxyphenyl)diphenylsilane dianhydride,
1,4-bis(3,4-dicarboxyphenyldimethylsilyl)benzene dianhydride,
1,3-bis(3,4-dicarboxyphenyl)-1,1,3,3-tetramethyldicyclohexane dianhydride,
15 p-phenylenebis(trimellitate anhydride),
ethylenetetracarboxylic dianhydride,
1,2,3,4-butanetetracarboxylic dianhydride,
decahydronaphthalene-1,4,5,8-tetracarboxylic dianhydride,
4,8-dimethyl-1,2,3,5,6,7-hexahydronaphthalene-1,2,5,6-tetracarboxylic dianhydride,
20 cyclopentane-1,2,3,4-tetracarboxylic dianhydride,
pyrrolidine-2,3,4,5-tetracarboxylic dianhydride,
1,2,3,4-cyclobutanetetracarboxylic dianhydride,
bis(exo-bicyclo[2,2,1]heptane-2,3-dicarboxylic dianhydride)sulfone,
25 bicyclo-(2,2,2)-octo-7-ene-2,3,5,6-tetracarboxylic dianhydride,

- 2,2-bis(3,4-dicarboxyphenyl)hexafluoropropane dianhydride,
2,2-bis[4-(3,4-dicarboxyphenoxy)phenyl]hexafluoropropane
dianhydride,
4,4'-bis(3,4-dicarboxyphenoxy)diphenylsulfide dianhydride,
5 1,4-bis(2-hydroxyhexafluoroisopropyl)benzenebis(trimellitic
anhydride),
1,3-bis(2-hydroxyhexafluoroisopropyl)benzenebis(trimellitic
anhydride),
5-(2,5-dioxotetrahydrofuryl)-3-methyl-3-cyclohexene-1,2-
10 dicarboxylic dianhydride, and
tetrahydrofuran-2,3,4,5-tetracarboxylic dianhydride.
Any of these may be used in the form of a mixture of two or more
kinds.

- Diamines used as starting materials for the polyimide resin
15 include aromatic diamines such as:
o-phenylenediamine,
m-phenylenediamine,
p-phenylenediamine,
3,3'-diaminodiphenyl ether,
20 3,4'-diaminodiphenyl ether,
4,4'-diaminodiphenyl ether,
3,3'-diaminodiphenylmethane,
3,4'-diaminodiphenylmethane,
4,4'-diaminodiphenylmethane,
25 bis(4-amino-3,5-dimethylphenyl)methane,
bis(4-amino-3,5-diisopropylphenyl)methane,

- 3,3'-diaminodiphenyldifluoromethane,
3,4'-diaminodiphenyldifluoromethane,
4,4'-diaminodiphenyldifluoromethane,
3,3'-diaminodiphenyl sulfone,
5 3,4'-diaminodiphenyl sulfone,
4,4'-diaminodiphenyl sulfone,
3,3'-diaminodiphenyl sulfide,
3,4'-diaminodiphenyl sulfide,
4,4'-diaminodiphenyl sulfide,
10 3,3'-diaminodiphenyl ketone,
3,4'-diaminodiphenyl ketone,
4,4'-diaminodiphenyl ketone,
2,2-bis(3-aminophenyl)propane,
2,2'-(3,4'-diaminodiphenyl)propane,
15 2,2-bis(4-aminophenyl)propane,
2,2-bis(3-aminophenyl)hexafluoropropane,
2,2-(3,4'-diaminodiphenyl)hexafluoropropane,
2,2-bis(4-aminophenyl)hexafluoropropane,
1,3-bis(3-aminophenoxy)benzene,
20 1,4-bis(3-aminophenoxy)benzene,
1,4-bis(4-aminophenoxy)benzene,
3,3'-(1,4-phenylenebis(1-methylethylidene))bisaniiline
3,4'-(1,4-phenylenebis(1-methylethylidene))bisaniiline
4,4'-(1,4-phenylenebis(1-methylethylidene))bisaniiline
25 2,2-bis(4-(3-aminophenoxy)phenyl)propane,
2,2-bis(4-(4-aminophenoxy)phenyl)propane,

- 2,2-bis(4-(3-aminophenoxy)phenyl)hexafluoropropane,
2,2-bis(4-(4-aminophenoxy)phenyl)hexafluoropropane,
bis(4-(3-aminophenoxy)phenyl)sulfide,
bis(4-(4-aminophenoxy)phenyl)sulfide,
5 bis(4-(3-aminophenoxy)phenyl)sulfone, and
bis(4-(4-aminophenoxy)phenyl)sulfone;
and aliphatic diamines such as:
- 1,2-diaminoethane,
1,3-diaminopropane,
10 1,4-diaminobutane,
1,5-diaminopentane,
1,6-diaminohexane,
1,7-diaminoheptane,
1,8-diaminooctane,
15 1,9-diaminononane,
1,10-diaminodecane,
1,11-diaminoundecane, and
1,12-diaminododecane.
- Any of these may be used in the form of a mixture of two or more
20 kinds.

- The polyimide can be obtained by subjecting the
tetracarboxylic dianhydride and the diamine to condensation by a
known method. More specifically, using the tetracarboxylic
dianhydride and the diamine in substantially equimolar weights
25 (the respective components may be added in any order), the
reaction is carried out in an organic solvent at a reaction

temperature of 80°C or below, and preferably at 0°C to 50°C. With the progress of the reaction, the viscosity of reaction mixture gradually increases, so that a polyimide precursor polyamic acid is formed.

- 5 The polyimide can be obtained by dehydration ring closure of the above reaction product (polyamic acid). The dehydration ring closure may be carried out by a method of heat treatment at 120°C to 250°C or by a chemical method.

- 10 Epoxy resin of glycidyl ether type, glycidylamine type, glycidyl ester type or alicyclic type may be used as organic materials for the filmy organic die-bonding materials of the present invention.

- As mentioned above, in the process for the fabrication of a semiconductor device according to the present invention, the die bonding may preferably be carried out under conditions of a temperature of from 100°C to 350°C, a bonding time of from 0.1 second to 20 seconds and a pressure of from 0.1 gf/mm² to 30 gf/mm². More preferably, it is carried out under conditions of a temperature of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 2 seconds and a pressure of 0.1 gf/mm² to 40 gf/mm², and the most preferably, under conditions of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 1.5 (exclusive) seconds and a pressure of 0.3 gf/mm² to 2 gf/mm².
- 15 As mentioned above, in the process for the fabrication of a semiconductor device according to the present invention, the die bonding may preferably be carried out under conditions of a temperature of from 100°C to 350°C, a bonding time of from 0.1 second to 20 seconds and a pressure of from 0.1 gf/mm² to 30 gf/mm². More preferably, it is carried out under conditions of a temperature of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 2 seconds and a pressure of 0.1 gf/mm² to 40 gf/mm², and the most preferably, under conditions of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 1.5 (exclusive) seconds and a pressure of 0.3 gf/mm² to 2 gf/mm².
- 20 When a filmy organic die-bonding material whose elastic modulus at a temperature of 250 °C is not more than 10 MPa is used, a sufficient peel strength (for example, 0.5 Kgf/5 × 5 mm

- 25 When a filmy organic die-bonding material whose elastic modulus at a temperature of 250 °C is not more than 10 MPa is used, a sufficient peel strength (for example, 0.5 Kgf/5 × 5 mm

chip or more) can be obtained by carrying out die-bonding under conditions of a temperature of from 150°C to 250 °C, a bonding time of 0.1 (inclusive) second to 2 seconds and a pressure of 0.1 gf/mm² to 4 gf/mm².

5

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 cross-sectionally illustrates an example of a process for fabricating the semiconductor device of the present invention.

10

Fig. 2 is a front elevation used to describe a method for measuring peel strength by using a push-pull gauge.

Fig. 3 is a plan view of an example of lead frames having a die pads.

15

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention will be described below in greater detail by giving Examples, but an embodiment of the present invention is not limited to these examples. All of polyimides used in the following examples are obtained by heating the mixture of acid dianhydride with diamine being the same mol as the acid dianhydride, in solvent, so as to polymerize them. In the following examples, polyimide A is a polyimide synthesized from 1,2-(ethylene)bis(trimellitate anhydride) and bis(4-amino-3,5-dimethylphenyl)methane; polyimide B is a polyimide synthesized from 1,2-(ethylene)bis(trimellitate anhydride) and 4,4'-

- diaminodiphenylether; polyimide C is a polyimide synthesized from 1,2-(ethylene)bis(trimellitate anhydride) and bis(4-amino-3,5-diisopropylphenyl)methane; polyimide D is a polyimide synthesized from 1,2-(ethylene)bis(trimellitate anhydride) and 2,2-bis[4-(4-aminophenoxy)phenyl] propane; polyimide E is a polyimide synthesized from a mixture of 1,2-(ethylene)bis(trimellitate anhydride) and 1,10-(decamethylene)bis(trimellitate anhydride) being the same mol as the mixture, and 2,2-bis[4-(4-aminophenoxy)phenyl] propane; polyimide F is a polyimide synthesized from 1,10-(decamethylene)bis(trimellitate anhydride) and 2,2-bis[4-(4-aminophenoxy)phenyl] propane.

Example 1

- To 100 g of each polyimide shown in Table 1 and 10 g of epoxy resin, 280 g of an organic solvent was added to make a solution. To the solution obtained, silver powder was added in a stated amount, followed by thorough stirring so as to be homogeneously dispersed, to obtain a coating varnish.

- This coating varnish was coated on a carrier film (OPP film; biaxially stretched polypropylene), followed by drying in a dryer with internal air circulation to cause the solvent to evaporate and dry the varnish. Thus, filmy organic die-bonding materials having the composition and water absorption as shown in Table 1 were prepared.

- The filmy organic die-bonding materials as shown in Table 1 were each stuck onto the tab of the lead frame while heating at

160°C. On the lead frame to which the filmy organic die-bonding material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions of a temperature of 300°C, a pressure of 12.5 gf/mm² and a bonding time of 5 seconds, followed by wire bonding and then molding with an encapsulant material (trade name CEL-9000, available from Hitachi Chemical Co., Ltd.). Thus, a semiconductor device was fabricated (QFP (Quad Flat Package) package: 14 × 20 × 1.4 mm; chip size: 8 × 10 mm; 42 alloy lead frame).

- 10 The semiconductor device having been thus encapsulated was treated in a thermo-hygrostat of 85°C and 85%RH for 168 hours, and thereafter heated at 240°C for 10 seconds in an IR (infrared) reflow furnace.

- 15 Thereafter, the semiconductor device was molded with polyester resin, and then cut with a diamond cutter to observe its cross section on a microscope. Rate (%) of occurrence of reflow cracks was measured according to the following expression to make evaluation on the reflow crack resistance.

- (Number of occurrence of reflow cracks/number of tests) × 100 =
20 rate (%) of occurrence of reflow cracks.

The results of evaluation are shown in Table 1.

Table 1

No.	Composition of film		Water absorption	Rate of occurrence of reflow cracks
	Polyimide	Ag content (wt.%)		
5	1	Polyimide A 80	2.0	100
10	2	Polyimide B 80	1.9	100
	3	Polyimide C 80	1.8	100
	4	Polyimide D 52	1.5	0
	5	Polyimide E 60	1.2	0
15	6	Polyimide E 0	1.0	0
	7	Polyimide F 60	0.9	0
	8	Polyimide F 0	0.8	0
	9	Polyimide F 40	0.7	0
	10	Polyimide F 80	0.4	0

Comparative Example:

20	Silver paste*	1.7	100
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* As the silver paste, EPINAL (trade name; available from Hitachi Chemical Co., Ltd.) was used.

- Measurement of Water Absorption -

A film with a size of 50 × 50 mm is used as a sample. The sample is dried at 120°C for 3 hours in a vacuum dryer, and then left to cool in a desiccator. Thereafter, the dried weight of the sample is measured and is regarded as M1. The sample is

immersed in distilled water at room temperature for 24 hours, and then taken out. The surface of the sample is wiped with filter paper and its weight is immediately measured and is regarded as M2.

- 5 The water absorption is calculated according to the following:

$$[(M2-M1)/(M1/d)] \times 100 = \text{Water absorption (vol.\%)}$$

wherein d is the density of the filmy organic die-bonding material.

10 Example 2

- To 100 g of each polyimide shown in Table 2 and 10 g of epoxy resin, 280 g of an organic solvent was added to make a solution. To the solution obtained, silver powder was added in a stated amount, followed by thorough stirring so as to be
15 homogeneously dispersed, to obtain a coating varnish.

- This coating varnish was coated on a carrier film (OPP film; biaxially stretched polypropylene), followed by drying in a dryer with internal air circulation to cause the solvent to evaporate and dry the varnish. Thus, filmy organic die-bonding materials having
20 the composition and saturation moisture absorption as shown in Table 2 were prepared.

- The filmy organic die-bonding materials as shown in Table 2 were each stuck onto the tab of the lead frame while heating at 160°C. On the lead frame to which the filmy organic die-bonding
25 material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions of a temperature of

300°C, a pressure of 12.5 gf/mm² and a bonding time of 5 seconds in examples No. 1 to 6 and the comparative example, and under conditions of a temperature of 230°C, a pressure of 0.6 gf/mm² and a bonding time of 1 second in examples No. 7 to 10, followed by wire bonding and then molding with an encapsulant material (trade name CEL-9000, available from Hitachi Chemical Co., Ltd.). Thus, a semiconductor device was fabricated (QFP package: 14 × 20 × 1.4 mm; chip size: 8 × 10 mm; 42 alloy lead frame).

The semiconductor device having been thus encapsulated was treated in a thermo-hygrostat of 85°C and 85%RH for 168 hours, and thereafter heated at 240°C for 10 seconds in an IR reflow furnace.

Thereafter, the semiconductor device was molded with polyester resin, and then cut with a diamond cutter to observe its cross section on a microscope. Rate (%) of occurrence of reflow cracks was measured according to the following expression to make evaluation on the reflow crack resistance.

$$(\text{Number of occurrence of reflow cracks} / \text{number of tests}) \times 100 = \text{rate (\%)} \text{ of occurrence of reflow cracks.}$$

The results of evaluation are shown in Table 2.

Table 2

Table 2					
	No.	Composition of film		Saturation moisture absorption	Rate of occurrence of reflow cracks
		Polyimide	Ag content (wt.%)		
5	1	Polyimide A	80	1.7	100
	2	Polyimide B	80	1.5	100
	3	Polyimide C	80	1.4	100
	4	Polyimide D	80	1.0	0
10	5	Polyimide D	60	0.8	0
	6	Polyimide D	40	0.6	0
	7	Polyimide F	0	0.5	0
	8	Polyimide F	60	0.4	0
	9	Polyimide F	52	0.3	0
15	10	Polyimide F	40	0.2	0

Comparative Example:

Silver paste*	1.2	100
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* As the silver paste, EPINAL (trade name; available from Hitachi Chemical Co., Ltd.) was used.

20 - Measurement of Saturation Moisture Absorption -

A circular filmy organic die-bonding material of 10 mm diameter is used as a sample. The sample is dried at 120°C for 3 hours in a vacuum dryer, and then left to cool in a desiccator.

Thereafter, the dried weight of the sample is measured and is regard as M1. The sample is moisture-absorbed in a thermo-hygrostat of 85°C and 85%RH, and then taken out. Its weight is immediately measured until the values of weight become

constant. This weight is regarded as M2.

The saturation moisture absorption is calculated according to the following:

$$[(M2-M1)/(M1/d)] \times 100 =$$

5 saturation moisture absorption (vol.%)

wherein d is the density of the filmy organic die-bonding material.

Example 3

To 100 g of polyimide F and 10 g of epoxy resin, 140 g of
10 dimethylacetamide and 140 g of cyclohexanone were added as
organic solvents to make a solution. To the solution obtained, 74
g of silver powder was added, followed by thorough stirring so as
to be homogenously dispersed, to obtain a coating varnish.

This coating varnish was coated on a carrier film (OPP film;
15 biaxially stretched polypropylene), followed by heating at
temperatures of from 80°C to 120°C in a dryer with internal air
circulation to cause the solvent to evaporate and dry the varnish.
Thus, filmy organic die-bonding materials having the residual
volatile component as shown in Table 3 were prepared. Here,
20 when the drying temperature was higher than 120°C, the coating
was dried on the OPP film at 80°C for 30 minutes, and thereafter
the resulting filmy organic die-bonding material was peeled from
the OPP film, which was then held on an iron frame, and again
heated in the dryer to dry it.

25 The filmy organic die-bonding materials as shown in Table 3
were each stuck onto the tab of the lead frame while heating at

160°C. On the lead frame to which the filmy organic die-bonding material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions of a temperature of 230°C, a pressure of 0.6 gf/mm² and a bonding time of 1 second, followed by wire bonding and then molding with an encapsulant material (trade name CEL-9000, available from Hitachi Chemical Co., Ltd.). Thus, a semiconductor device was fabricated (QFP package: 14 × 20 × 1.4 mm; chip size: 8 × 10 mm; 42 alloy lead frame).

- 10 The semiconductor device having been thus encapsulated was treated in a thermo-hygrostat of 85°C and 85%RH for 168 hours, and thereafter heated at 240°C for 10 seconds in an IR reflow furnace.

- 15 Thereafter, the semiconductor device was molded with polyester resin, and then cut with a diamond cutter to observe its cross section on a microscope. Rate (%) of occurrence of reflow cracks was measured according to the following expression to make evaluation on the reflow crack resistance.

- (Number of occurrence of reflow cracks/number of tests) × 100 =
20 rate (%) of occurrence of reflow cracks.

The results of evaluation are shown in Table 3.

Table 3

5	No.	Drying temp.	Drying time	Residual volatile component	Voids in film	Rate of occurrence of reflow cracks
		(C°)	(min)	(wt.%)		(%)
	1	80	30	6.5	Present	100
	2	100	2	4.9	Present	100
	3	100	4	4.2	Present	100
10	4	100	10	3.8	Present	80
	5	100	30	3.5	Present	60
	6	120	10	3.0	None	0
	7	120	75	2.2	None	0
	8	140	10	2.0	None	0
15	9	160	10	1.5	None	0
	10	140	60	1.2	None	0
	11	160	30	0.7	None	0

Comparative Example:

Silver paste*	15.0	Present	100
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- 20 * As the silver paste, EPINAL (trade name; available from Hitachi Chemical Co., Ltd.) was used.

- Measurement of Residual Volatile Component -

- A filmy organic die-bonding material with a size of 50 × 50 mm is used as a sample. The weight of the sample is measured and is regarded as M1. The sample is heated at 200°C for 2 hours in a hygrostat with internal air circulation, and thereafter its weight is immediately measured and is regarded as M2.
- 25

The residual volatile component is calculated according to

the following:

$$[(M2-M1)/M1] \times 100 = \text{residual volatile component (wt.\%)}$$

Example 4

To 100 g of polyimide D and 10 g of epoxy resin, 140 g of dimethylacetamide and 140 g of cyclohexanone were added as organic solvents to make a solution. To the solution obtained, 74 g of silver powder was added, followed by thorough stirring so as to be homogeneously dispersed, to obtain a coating varnish.

This coating varnish was coated on a carrier film (OPP film; biaxially stretched polypropylene), followed by heating at temperatures of from 80°C to 120°C in a dryer with internal air circulation to cause the solvent to evaporate and dry the varnish. Thus, filmy organic die-bonding materials having the void volume as shown in Table 4 were prepared. Here, when the drying temperature was higher than 120°C, the coating was dried on the OPP film at 80°C for 30 minutes, and thereafter the resulting filmy organic die-bonding material was peeled from the OPP film, which was then held on an iron frame, and again heated in the dryer to dry it.

Herein, the void volume refers to a void volume in terms of voids present in the die-bonding material and at the interface between the die-bonding material and the support member at the stage where the semiconductor chip is bonded to the support member.

The filmy organic die-bonding materials as shown in Table 4 were each stuck onto the tab of the lead frame while heating at

160°C. On the lead frame to which the filmy organic die-bonding material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions of a temperature of 300°C, a pressure of 12.5 gf/mm² and a bonding time of 5 seconds, followed by wire bonding and then molding with an encapsulant material (trade name CEL-9000, available from Hitachi Chemical Co., Ltd.). Thus, a semiconductor device was fabricated (QFP package: 14 × 20 × 1.4 mm; chip size: 8 × 10 mm; 42 alloy lead frame).

The semiconductor device having been thus encapsulated was treated in a thermo-hygrostat of 85°C and 85%RH for 168 hours, and thereafter heated at 240°C for 10 seconds in an IR reflow furnace.

Thereafter, the semiconductor device was molded with polyester resin, and then cut with a diamond cutter to observe its cross section on a microscope. Rate (%) of occurrence of reflow cracks was measured according to the following expression to make evaluation on the reflow crack resistance.

(Number of occurrence of reflow cracks/number of tests) × 100 =

rate (%) of occurrence of reflow cracks.

The results of evaluation are shown in Table 4.

Table 4

No.	Drying temp. (C°)	Drying time (min)	Void volume (wt.%)	Rate of occurrence of reflow cracks (%)
5	1	80	30	100
	2	100	2	100
	3	100	10	80
	4	120	10	0
	5	120	75	0
10	6	140	10	0
	7	160	30	0

Comparative Example:

Silver paste*	40	100
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- * As the silver paste, EPINAL (trade name; available from Hitachi Chemical Co., Ltd.) was used.

- Measurement of Void Volume -

- A silicone chip is bonded to a lead frame using the filmy organic die-bonding material to make a sample. A photograph of a top view of the sample is taken using a soft X-ray device. The area percentage of voids in the photograph is measured using an image analyzer, and the area percentage of the voids seen through the sample from its top is regarded as void volume (%).

Example 5

- To 100 g of each polyimide shown in Table 5 and 10 g of epoxy resin, 280 g of an organic solvent was added to make a solution. To the solution obtained, silver powder was added in a stated amount, followed by thorough stirring so as to be

homogeneously dispersed, to obtain a coating varnish.

This coating varnish was coated on a carrier film (OPP film; biaxially stretched polypropylene), followed by drying in a dryer with internal air circulation to cause the solvent to evaporate and dry the varnish. Thus, filmy organic die-bonding materials having the composition and peel strength as shown in Table 5 were prepared.

Herein, the peel strength refers to the peel strength of the filmy organic die-bonding material at the stage where the semiconductor chip is bonded to the support member through the filmy organic die-bonding material.

The filmy organic die-bonding materials as shown in Table 5 were each stuck onto the tab of the lead frame while heating at 160°C. On the lead frame to which the filmy organic die-bonding material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions of a temperature of 300°C, a pressure of 12.5 gf/mm² and a bonding time of 5 seconds with respect to examples No. 1 to 5, and conditions of a temperature of 230°C, a pressure of 0.6 gf/mm² and a bonding time of 1 second with respect to examples No. 6 to 10, followed by wire bonding and then molding with an encapsulant material (trade name CEL-9000, available from Hitachi Chemical Co., Ltd.). Thus, a semiconductor device was fabricated (QFP package: 14 × 20 × 1.4 mm; chip size: 8 × 10 mm; 42 alloy lead frame).

The semiconductor device having been thus encapsulated was treated in a thermo-hygrostat of 85°C and 85%RH for 168

hours, and thereafter heated at 240°C for 10 seconds in an IR reflow furnace.

Thereafter, the semiconductor device was molded with polyester resin, and then cut with a diamond cutter to observe its cross section on a microscope. Rate (%) of occurrence of reflow cracks was measured according to the following expression to make evaluation on the reflow crack resistance.

$$\text{rate (\%)} = \frac{\text{Number of occurrence of reflow cracks}}{\text{number of tests}} \times 100$$

The results of evaluation are shown in Table 5.

Table 5

No.	<u>Composition of film</u>		Peel strength (Kgf/ 5 × 5 mm chip)	Rate of occurrence of reflow cracks (%)
	Polyimide	Ag content (wt.%)		
15	1	Polyimide B 80	0.2	100
	2	Polyimide C 80	0.3	100
	3	Polyimide A 80	0.4	80
20	4	Polyimide D 80	0.5	0
	5	Polyimide F 80	0.7	0
	6	Polyimide F 0	0.8	0
	7	Polyimide F 30	1.0	0
25	8	Polyimide F 20	1.5	0
	9	Polyimide F 40	>2.0	0
10	10	Polyimide F 52	>2.0	0

Method of measuring a peel strength

- On a support member, such as a tab surface of a lead frame, for supporting semiconductor chips, a silicone chip (test piece) of 5×5 mm was attached by laying a filmy organic die-bonding materials therebetween. The chip-attached support member was held on a heating platen heated at a temperature of 240°C for 20 seconds. As shown in Fig. 2, a peel strength was measured by a push-pull gauge at a test speed of 0.5 mm/minute. In Fig. 2, reference numeral 21 represents a semiconductor chip, 22 represents a filmy organic die-bonding material, 23 represents a lead frame, 24 represents the push-pull gauge, 25 represents the heating platen. In this case, the test piece was held at a temperature of 240°C for 20 seconds, but in a case where a semiconductor device is packaged at a different temperature depending on its purpose, the measurement must be performed at the temperature.

Example 6

- To 100 g of polyimide E and 10 g of epoxy resin, 280 g of an organic solvent was added to make a solution. To the solution obtained, silver powder was added in a stated amount, followed by thorough stirring so as to be homogeneously dispersed, to obtain a coating varnish.

- This coating varnish was coated on a carrier film (OPP film; biaxially stretched polypropylene), followed by drying in a dryer with internal air circulation to cause the solvent to evaporate and dry the varnish. Thus, filmy organic die-bonding materials were

prepared.

- The filmy organic die-bonding materials, having the size as shown in Table 6, were each stuck onto the tab of the lead frame while heating at 160°C. On the lead frame to which the filmy
- 5 organic die-bonding material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions of a temperature of 300°C, a pressure of 12.5 gf/mm² and a bonding time of 5 seconds, followed by wire bonding and then molding with an encapsulant material (trade name CEL-9000, available
- 10 from Hitachi Chemical Co., Ltd.). Thus, a semiconductor device was fabricated (QFP package: 14 × 20 × 1.4 mm; chip size: 8 × 10 mm; 42 alloy lead frame).

- The semiconductor device having been thus encapsulated was treated in a thermo-hygrostat of 85°C and 85%RH for 168
- 15 hours, and thereafter heated at 240°C for 10 seconds in an IR reflow furnace.

- Thereafter, the semiconductor device was molded with polyester resin, and then cut with a diamond cutter to observe its cross section on a microscope. Rate (%) of occurrence of reflow
- 20 cracks was measured according to the following expression to make evaluation on the reflow crack resistance.
- (Number of occurrence of reflow cracks/number of tests) × 100 = rate (%) of occurrence of reflow cracks.

The results of evaluation are shown in Table 6.

Table 6

	No.	Film size (mm)	Planar dimension of film (mm ²)	Chip size (mm)	Planar dimension of chip	Outward protrusion	Rate of occurrence of reflow cracks (%)
5	1	11×13	143	8×10	80	Yes	100
	2	10×12	123	8×10	80	Yes	100
	3	9×11	99	8×10	80	Yes	100
10	4	9×10	90	8×10	80	Yes	70
	5	8×11	88	8×10	80	Yes	60
	6	8×10	80	8×10	80	No	0
	7	8×9	72	8×10	80	No	0
	8	7×10	70	8×10	80	No	0
15	9	8×9	72	8×10	80	No	0
	10	6×8	48	8×10	80	No	0
	11	5×7	35	8×10	80	No	0
	12	4×6	24	8×10	80	No	0
	13	3×5	15	8×10	80	No	0
20	14	2×4	8	8×10	80	No	0

Example 7

To 100 g of polyimide F and 10 g of epoxy resin, 280 g of an organic solvent was added to make a solution. To the solution obtained, silver powder was added in a stated amount, followed by thorough stirring so as to be homogeneously dispersed, to obtain a coating varnish.

This coating varnish was coated on a carrier film (OPP film; biaxially stretched polypropylene), followed by drying in a dryer

with internal air circulation to cause the solvent to evaporate and dry the varnish. Thus, filmy organic die-bonding materials were prepared.

- 5 The filmy organic die-bonding materials, having the modulus of elasticity at a temperature of 250 °C as shown in Table 7, were each stuck onto the tab of the lead frame while heating at 160°C. On the lead frame to which the filmy organic die-bonding material was thus stuck, a semiconductor chip was mounted by die bonding carried out under conditions shown in Table 7.

10

Table 7							
15	Composition of film		Film modulus of elastic (MPa)	Conditions		Peel strength (Kg/5 × 5mm chip)	
	No. Polyimide	Ag content (wt.%)		Temperature (°C)	Pressure (gf/mm ²)		
	1	Polyimide F	6.0	0.2	230 2.0	>2.0	
	2	Polyimide F	4.0	0.3	230 2.0	>2.0	
	3	Polyimide F	0	0.4	230 2.0	0.8	

- 20 Method of measuring a film modulus of elasticity (MPa)
By using RHEOLOGRAPH OF SOLID S type, available from Kabushiki Kaisha Toyoseiki Seisakusho, a dynamic viscoelasticity was measured at a heating speed of 5 °C/minute and a frequency of 10Hz. A storage modulus E' at a temperature of 250 °C was regarded as the modulus of elasticity.

- 25 Method of measuring a peel strength
It is as same as that of Example 5.

What is calimed is:

1 1. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin
4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film having a water absorption of 1.5% by volume or
8 less.

1 2. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin
4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film having a saturation moisture absorption of 1.0%
8 by volume or less.

1 3. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin
4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film having a residual volatile component in an

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8 amount not more than 3.0% by weight.

1 4. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin
4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film having a modulus of elasticity of 10 MPa or less
8 at a temperature of 250 °C.

1 5. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin
4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film having, at the stage where the semiconductor
8 chip has been bonded to the support member, a void volume of 10%
9 or less in terms of voids present in the die-bonding material and
10 at the interface between the die-bonding material and the support
11 member.

1 6. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin

4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film having a peel strength of $0.5 \text{ Kg}/5 \times 5 \text{ mm}$ chip
8 or above at the stage where the semiconductor chip has been
9 bonded to the support member.

1 7. A semiconductor device comprising a support member, a
2 semiconductor chip, a die-bonding material for attaching the
3 semiconductor chip to the support member, and a resin
4 encapsulant member for encapsulating the semiconductor chip,
5 wherein:

6 said die-bonding material is a film containing an organic
7 matter; said film i) having a planar dimension not larger than the
8 planar dimension of the semiconductor chip, and ii) not protruding
9 outward from the region of the semiconductor chip at the stage
10 where the semiconductor chip has been bonded to the support
11 member.

1 8. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin:

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter; said filmy die-bonding
7 material having a water absorption of 1.5% by volume or less.

1 9. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter; said filmy die-bonding
7 material having a saturation moisture absorption of 1.0% by
8 volume or less.

1 10. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter; said filmy die-bonding
7 material having a residual volatile component in an amount not
8 more than 3.0% by weight.

1 11. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter; said filmy die-bonding
7 material having a modulus of elasticity of 10 MPa or less at a

8 temperature of 250 °C.

1 12. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter; said filmy die-bonding
7 material having, at the stage where the semiconductor chip has
8 been bonded to the support member, a void volume of 10% or less
9 in terms of voids present in the die-bonding material and at the
10 interface between the die-bonding material and the support
11 member.

1 13. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with die-bonding material
6 comprising a filmy die-bonding material containing an organic
7 matter; said filmy die-bonding material having a peel strength of
8 0.5 kgf/5 × 5 mm chip or above at the stage where the
9 semiconductor chip has been bonded to the support member.

1 14. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a

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3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter; said filmy die-bonding
7 material i) having a planar dimension not larger than the planar
8 dimension of the semiconductor chip, and ii) not protruding
9 outward from the region of the semiconductor chip at the stage
10 where the semiconductor chip has been bonded to the support
11 member.

1 15. A process for fabricating a semiconductor device,
2 comprising the steps of attaching a semiconductor chip to a
3 support member, and encapsulating the semiconductor chip with a
4 resin;

5 said attaching being carried out with a filmy die-bonding
6 material containing an organic matter;
7 the process further comprising the steps of
8 mounting said semiconductor chip on said filmy die-bonding
9 material; and

10 attaching said semiconductor chip to said filmy die-bonding
11 material under conditions of a temperature of 150°C to 250°C,
12 bonding time of 0.1 (inclusive) second to 2 seconds, and a
13 pressure of 0.1 to 4 gf/mm².

1 16. A process for fabricating a semiconductor device,
2 according to any one of claims 8 to 13 and 14, further comprising

3 the steps of

4 mounting said semiconductor chip on said filmy die-bonding
5 material; and

6 attaching said semiconductor chip to said filmy die-bonding
7 material under conditions of a temperature of 150°C to 250°C,
8 bonding time of 0.1 (inclusive) second to 2 seconds, and a
9 pressure of 0.1 to 4 gf/mm².

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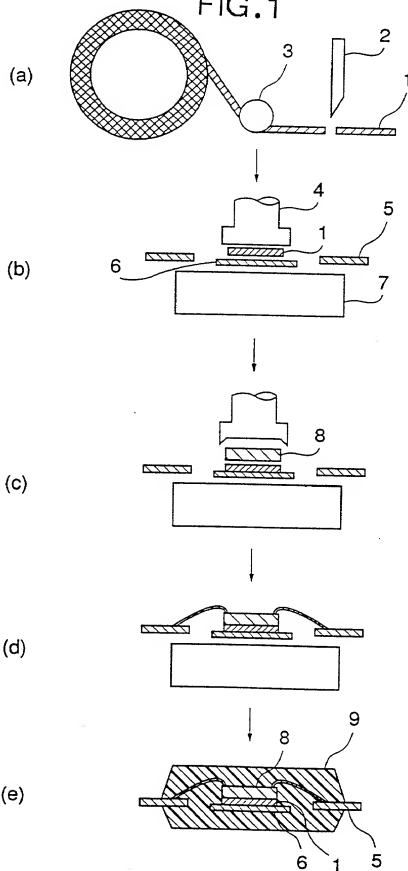
ABSTRACT OF THE DISCLOSURE

A semiconductor chip is attached to a lead frame with a
filmy organic die-bonding material having a water absorption of
5 1.5% by volume or less; having a saturation moisture absorption
of 1.0% by volume or less, having a residual volatile component in
an amount not more than 3.0% by weight, having a modulus of
elasticity of 10 MPa or less at a temperature of 250 °C. The
semiconductor device thus obtained can be free from occurrence
10 of reflow cracks during reflow soldering for the packaging of
semiconductor devices.

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FIG. 1



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FIG. 2

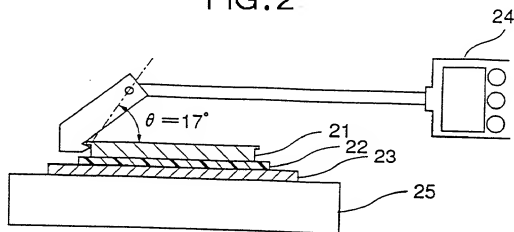


FIG. 3



DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor if only one name is listed at 201 below, or an original, first and joint inventor if plural names are listed at 201 et seq. below, of the subject matter which is claimed and for which a patent is sought on the invention entitled the specification of which: SEMICONDUCTOR DEVICE AND PROCESS FOR FABRICATION THEREOF

☐ is attached hereto ☒ was filed on July 8, 1996, as Application Serial No. 08/981,702 (for declaration not accompanying application)

with amendment(s) filed (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119/§172 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

EARLIEST FOREIGN APPLICATION(S), IF ANY, FILED PRIOR TO THE FILING DATE OF THE APPLICATION			
APPLICATION NUMBER	COUNTRY	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. 119/172
7-171154	Japan	06/07/1995	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
			YES <input type="checkbox"/> NO <input type="checkbox"/>
			YES <input type="checkbox"/> NO <input type="checkbox"/>
			YES <input type="checkbox"/> NO <input type="checkbox"/>

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NO.	FILING DATE	STATUS		
		PATENTED	PENDING	ABANDONED

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY		COUNTRY OF CITIZENSHIP
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE OR COUNTRY	ZIP CODE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
DATE	DATE	DATE